

Renal Resistance Index Predicting Outcome of Renal Revascularization for Renovascular Hypertension

Simone N. Santos¹, Luiz R. Leite¹, Tak Sun Tse², Rebecca Beck², Robert A. Lee², Roger F. J. Shepherd²

Hospital Brasília¹, Brasília, DF - Brazil; Mayo Clinic and Mayo Foundation², Rochester Minnesota

Abstract

Background: Renal artery stenosis (RAS) is a potentially correctable cause of hypertension and ischemic nephropathy. Despite successful renal revascularization, not all patients (pt) overcome it and some get worse.

Objective: This study was designed to assess the value of renal resistance index (RI) in predicting the outcome of renal revascularization.

Methods: Between Jan 1998 and Feb 2001, 2,933 pts were referred to renal duplex ultrasound. 106 out of these had significant RAS and underwent angiography and renal revascularization. Arterial blood pressure (BP) was measured before and after the intervention, at intervals of up to 2 years and medications recorded. Prior to revascularization, RI was measured at 3 sites of each kidney and averaged.

Results: Out of the 106 patients, 81 had RI < 80 and 25 RI ≥ 80. RAS was corrected with angioplasty (PTA) alone in 25 pts, PTA + stent in 56 pts and corrected by surgery in 25 pts. Of patients who benefited from renal revascularization; 57 of the 81 patients with RI < 80 improved as compared to 5 of 25 with RI ≥ 80. Using a multiple logistic regression model, RI was significantly associated with BP outcome (p=0.001), adjusted for the effects of age, sex, SBP, DBP, duration of hypertension, type of revascularization, number of medication in use, creatinine level, presence of diabetes mellitus, hypercholesterolemia, stroke, peripheral and coronary artery disease and kidney size (OR 99.6 - 95%CI for OR 6.1 to 1,621.2).

Conclusion: Intrarenal arterial resistance measured by duplex ultrasound plays an important role in predicting BP outcome after renal revascularization for RAS. (Arq Bras Cardiol 2010; 94(4):426-430)

Key words: Renal artery obstruction; hypertension, renovascular; renal insufficiency; kidney/surgery.

Introduction

Renal vascular disease due to renal artery stenosis (RAS) is an important cause of hypertension (HBP) and ischemic nephropathy. It accounts for up to half of patients with secondary hypertension and is also a common and increasing cause of end-stage renal disease affecting up to 120,000 in the USA.

Atherosclerosis accounts for 70% of these patients and arterial fibrodysplasia is the second leading cause of occlusive disease found in 20% to 25% of them^{1,2}. Although the prevalence is only 1% to 6% in the overall hypertensive patients³, it is a potentially curable cause of arterial hypertension and ischemic kidney failure.

Reports on the natural history of renal artery stenosis have shown progression of renal artery stenosis in 30% to 53% of patients monitored for up to 10 years^{4,5}. Loss of renal mass is also an important consequence of high-grade

renal artery stenosis⁶. It is clear that renal artery stenosis is a progressive disease and that this progression can be fast in some patients.

Unfortunately, despite successful renal revascularization, not all patients have improved control of high blood pressure and/or presented improved renal function⁷. Duplex ultrasound has been used to evaluate the results and follow-up of surgical as well as endovascular interventions^{8,9}. The main goal of our investigation was to assess the value of a duplex derived renal resistance index (RI) in predicting the outcome of revascularization in patients with renovascular disease seen in a tertiary care center.

Methods

We evaluated 2933 patients who had renal artery duplex ultrasound (US) studies performed between January 1998 and February 2001. We selected for further analysis by retrospective chart review 108 patients who met the criteria of our study definition, which was: high blood pressure, renal artery stenosis of more than 60% in duplex US and underwent renal revascularization by angioplasty, stenting or surgery. Two patients did not give consent for research proposal and were excluded. Our study population comprised 106 patients.

Mailing address: Simone Nascimento dos Santos •
SMDB CJ 16 Lote 5 CASA A - Lago Sul - 71680-160 - Brasília, DF - Brazil
E-mail: simonens@cardiol.br, sns2003@uol.com.br
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Patient's clinical features and ultrasound findings were compared in two groups of patients: with resistance index smaller than 80 and with resistance index greater or equal to 80. The clinical features were: age, sex, body mass index, smoking, severity and duration of high blood pressure, measurements of blood pressure before intervention and at follow-up visits up to 2 years. We also ascertained the presence of family history of high blood pressure, diabetes, hypercholesterolemia, coronary artery disease, peripheral artery disease, carotid and mesenteric artery disease. Diabetes was considered to be present if a patient was being treated with insulin or oral agents or had a fasting blood glucose level higher than 7.0 mmol/l (126 mg/dl). Dyslipidemia was considered to be present if the concentration of total cholesterol was greater than 6.21 mmol/l (240 mg/dl), the triglyceride level was greater than 2.26 mmol/l (200 mg/dl), or the high-density lipoprotein cholesterol level was smaller than 1.03 mmol/l (40 mg/dl). Renal function was analyzed looking at creatinine blood levels before intervention and at follow-up visits up to 2 years. Number and type of medication before and following intervention were recorded. Renal doppler ultrasound was performed using Sequoia™ (Siemens Medical Solutions USA Inc., Ultrasound Division, Mountain View, CA). The aorta and renal artery Doppler ultrasound findings analyzed were: aortic diameter; peak systolic velocity in the abdominal aorta; kidney size; degree of stenosis; peak systolic velocity, end-diastolic velocity, acceleration time in the upper, middle and lower renal pole (3 sites of each kidney and averaged). With these measurements, the resistance index was calculated using the following equation: $[1 - (\text{end-diastolic velocity} \div \text{peak systolic velocity})] \times 100$. All Doppler ultrasound findings were considered as an average of 3 measurements. Procedural technical success rate and complications were also reviewed.

Statistical analysis

Continuous data are expressed as mean \pm standard deviation. Statistical analysis was done using the SPSS package. Univariate comparisons of risk factors and other dichotomous variables between study groups were performed with χ^2 test. Continuous measures were evaluated with the Wilcoxon rank test or t-test as appropriate. Stepwise logistic regression was used to determine the association of the strong covariates to the RI.

Results

The entire cohort with 106 patients had a mean age of 70 years, 66 females and 40 males. Three fourth of patients had either recent onset of HBP (22.6%) or recent worsening of HBP (56.6%). Nearly half of them had bilateral renal artery disease (44.3%). The commonest etiology of RAS was atherosclerosis (ASO) in 85% of the patients and arterial fibrodysplasia (FMD) was found in 15% of them.

The treatment chosen was renal artery angioplasty in 24% of the patients, surgery in 24% and renal artery angioplasty/stenting in 56%.

We divided 106 patients into two groups based on RI: low RI (<80) - 81 patients; high RI (\geq 80) - 25 patients. The results are listed in Table 1. Patients with low RI were younger than

patients with high RI (68.7y x 74.3y - $p=0.009$). Patients with high RI were more likely to have peripheral artery disease (23.5% x 56% - $p=0.005$) and coronary artery disease (33.3% x 56% - $p=0.006$) than patients with low RI. Patients with high RI had a longer duration of HBP than patients with low RI (38.4 mths x 56 mths - $p=0.005$). Patients with high RI had a higher pulse pressure than patients with low RI (82.7 mmHg x 102 mmHg - $p=0.0003$).

The blood pressure outcome was classified as no benefit, improvement and cure (Figure 1). In 81 patients with low RI, the majority improved (57 patients) and 2 were cured. 22 patients had no benefit. In 25 patients with high RI 20 had no benefit and only 5 improved. Furthermore, looking at actual BP results post revascularization there was a significant difference in SBP being high for patients with high RI (157 mmHg x 143 mmHg - $p=0.04$).

After revascularization, patients with low RI required fewer medications for BP control than patients with high RI (Figure 2).

Table 1 - Baseline characteristics: two groups based on resistance index (total 106 patients)

	RI < 80 (n=81)	RI \geq 80 (n=25)	p value
Age (years)	68.7	74.3	0.009
Male	31 (38.3%)	9 (36%)	Ns
ASO	68 (83.9%)	22 (88%)	Ns
FMD	13 (16%)	3 (12%)	Ns
DM	10 (12.3%)	7 (28%)	Ns
Hyperlipidemia	68 (83.9%)	22 (88%)	Ns
Current smoker	13 (16%)	3 (12%)	Ns
Former smoker	29 (35.8%)	13 (52%)	Ns
Never smoker	36 (44.4%)	9 (36%)	Ns
Strong Family Hx of HBP	26 (32.1%)	11 (44%)	Ns
PAD	19 (23.5%)	14 (56%)	0.005
CAD	27 (33.3%)	14 (56%)	0.006
CVD	42 (51.8%)	16 (64%)	Ns
Duration of HBP	38.4 months	56 months	0.005
Recent onset of HBP	10 (12.3%)	7 (28%)	Ns
Recent worsening of HBP	42 (51.8%)	18 (72%)	Ns
SBP baseline	170.5 mmHg	180.8 mmHg	Ns
DBP baseline	87.8 mmHg	78.8 mmHg	0.002
Pulse pressure	82.7 mmHg	102 mmHg	0.0003
Baseline creatinine	1.5	1.5	Ns
Kidney size	10.7 mm	10.7 mm	Ns
Difference in kidney size	0.27 mm	0.52 mm	Ns

RI - resistance index; ASO - atherosclerosis; FMD - fibromuscular displasia; DM - diabetes mellitus; PAD - peripheral arterial disease; CAD - coronary artery disease; CVD - cerebro vascular disease; HBP - high blood pressure; SBP - systolic blood pressure; DBP - diastolic blood pressure.

For creatinine outcome, there were no differences between the two groups.

In multivariate analysis by logistic regression (Figure 3), using all possible predictor variables in the model, we found that RI was the most powerful predictor for no improvement in BP outcome (OR 99.6 - 95%CI 6.1-1621.2).

Discussion

Renal vascular disease due to renal artery stenosis is the most common cause of secondary hypertension. ASO accounts for 70% of these patients and FMD is the second leading cause of occlusive disease found in 20% to 25% of them². We found a similar pattern of distribution in etiology in our patients.

Long-term patency rates after surgical correction of RAS are probably better than angioplasty¹⁰. Even better technical results have been shown in patients treated with stents than with angioplasty alone¹¹⁻¹³. The technical success of renal revascularization does not guarantee an improvement in blood pressure control or renal function. In fact, cure of hypertension after renal revascularization is not frequent and is more common in patients with FMD than those with ASO renal disease (63% x 30.6%). After surgical or percutaneous revascularization, renal function improves in 40 to 55% of patients and deteriorates further in 14 to 30%¹. The Mayo experience in 320 patients examined the clinical outcomes where patients with ASO 70% benefited, but only 8% were cured. In patients with FMD, 63% improved but only 22% were cured¹⁴. In our study, from 81 patients with low RI, the

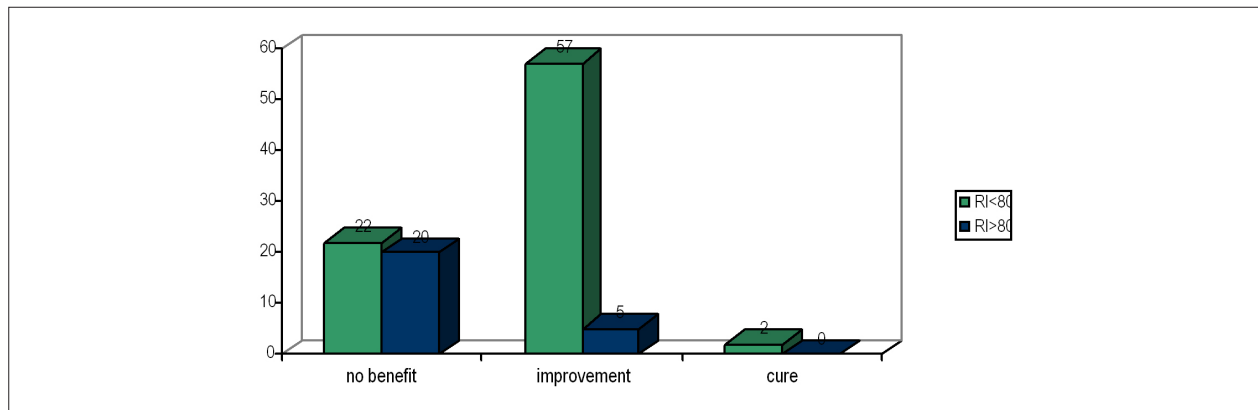


Figure 1 - Blood pressure outcome after renal artery revascularization: two groups based on resistance index (total 106 patients). RI - resistance index.

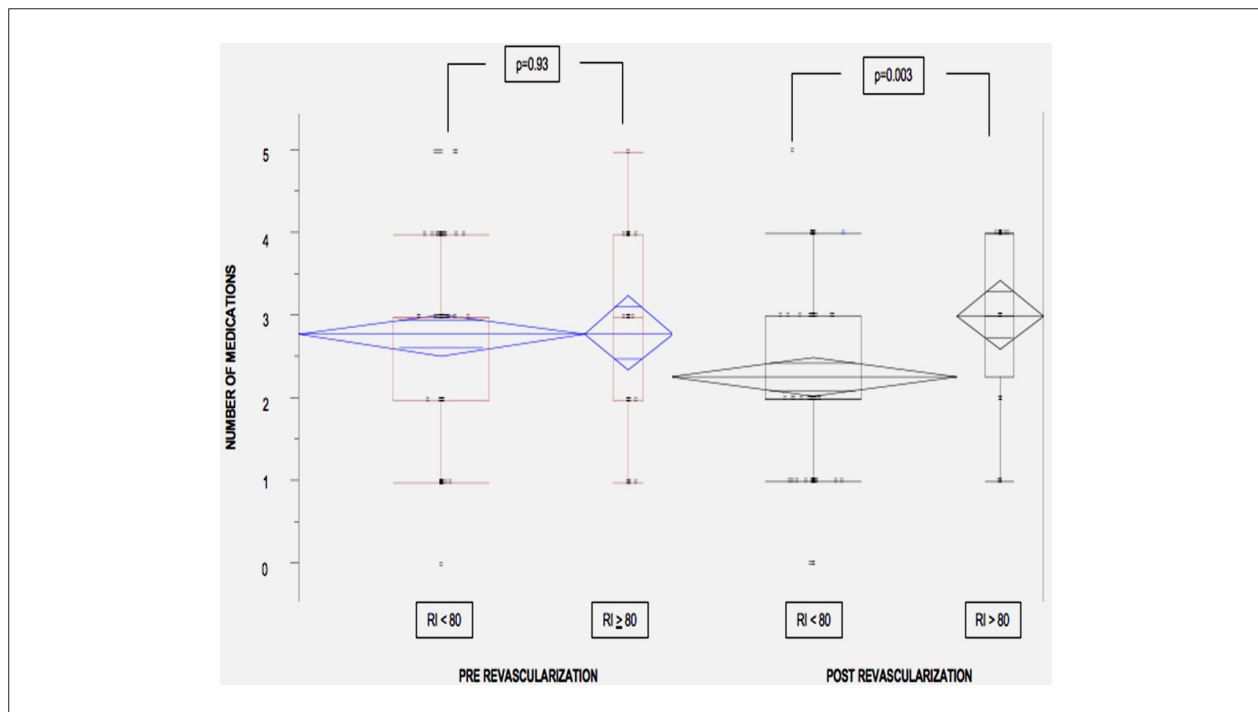


Figure 2 - Number of blood pressure medications pre and post renal artery revascularization.

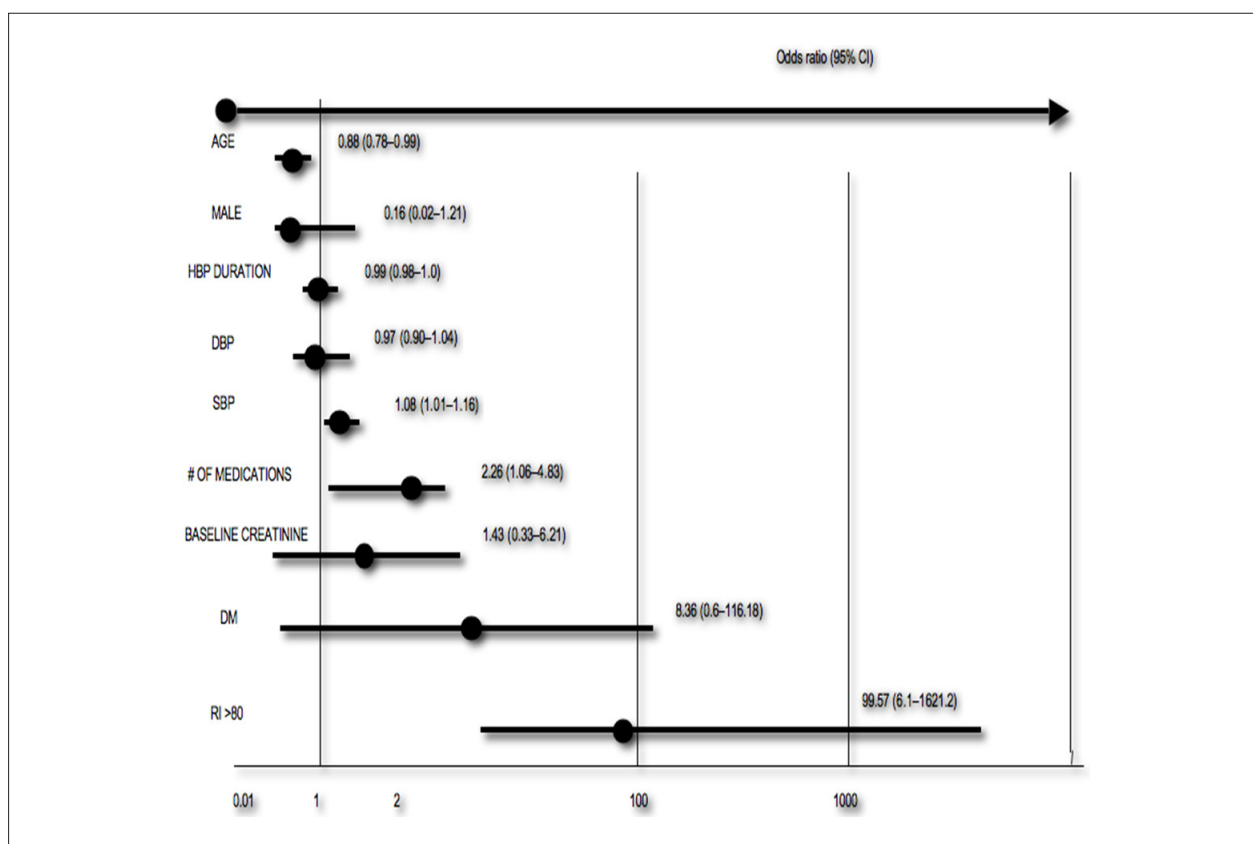


Figure 3 - Multivariate analysis for no improvement in blood pressure outcome after renal artery revascularization.

majority improved (57 patients) and 2 were cured. 22 patients had no benefit. In 25 patients with high RI 20 had no benefit and only 5 improved.

One possible reason for a poor outcome of renal artery revascularization may be an increased vascular resistance in the kidney parenchyma due to nephrosclerosis or glomerulosclerosis from long standing hypertension. Duplex ultrasound has been used to evaluate the results and follow-up of surgical as well as endovascular interventions^{3,15,16}. Few studies investigated whether a high level of resistance to flow in segmental renal arteries measured by duplex US could be used to select appropriate patients for treatment¹⁷⁻¹⁹. This study correlated a high RI measured by duplex US with failure to improve HBP after renal artery revascularization.

Our study showed that patients with high RI were older, had a higher probability of coexisting atherosclerosis in other beds such as peripheral arteries and coronary arteries, presented longer duration of HBP and high pulse pressure. These findings may be useful to identify a group of patients at higher risk for no improvement in BP outcome after renal artery revascularization. Although patients with high RI are at higher risk, multivariate analysis RI showed to be the most powerful independent predictor of no improvement in blood pressure outcome [OR 99.6 (95%CI 6.1-1621.2)]. Younger patients [OR 0.88 (95%CI 0.78-0.99)], higher SBP [OR 1.08 (95%CI 1.01-1.16)] and higher number of medications before intervention [OR 2.26 (95%CI 1.06-

4.83)] were also independently related to poor outcome with less statistic significance.

Conclusion

To conclude, a high renal parenchymal resistance index is associated with older age, coronary artery disease, peripheral artery disease, long standing hypertension, and high pulse pressure. Renal resistance index is a more powerful predictor of BP outcome after renal artery revascularization, than any clinical feature. A high renal resistance index correlates with a worse outcome after renal artery revascularization and may be a useful marker for those less likely to benefit from renal artery intervention.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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There were no external funding sources for this study.

Study Association

This study is not associated with any post-graduation program.

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